JOURNAL OF THE AMERICAN ROCKET SOCIETY

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NUMBER 74 JUNE, 1948

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JOURNAL OF THE AMERICAN ROCKET SOCIETY

NUMBER 74 **JUNE, 1948**

JAMES R. RANDOLPH, Editor

The JOURNAL OF THE AMERICAN ROCKET SOCIETY is devoted to the purpose of disseminating information on the development of the rocket and jet propulsion. This is accomplished by printing original technical papers on jet propulsion, data on the latest experimental developments, historical notes, patent specifications, reviews of books and current literature, and news of the Society and individual members.

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WORLD'S LARGEST RAM JET

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INYOKERN, CAL.—FEBRUARY 1, 1948

The largest supersonic ram jet engine ever flown attained a speed far into the supersonic range in its first test flight at the Naval Ordnance Test Station, Inyokern, California, Rear Admiral A. G. Noble, U.S.N., Chief of the Bureau of Ordnance, announced today. Pound for pound of engine weight, this large ram jet, popularly known as the "flying stovepipe," delivered about 25 times the power available from the best aircraft reciprocating engines. By comparison, the power developed by this simple engine was considerably in excess of the combined horsepower of the largest four-engine planes. The ram jet was designed by the Applied Physics Laboratory of Johns Hopkins and associated universities and industries. Bendix Aviation Corporation designed the fuel control system.

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R. H. GODDARD ROCKET IN FLIGHT, AUG. 26, 1937

JOURNAL OF THE AMERICAN ROCKET SOCIETY

Number 74 JAMES R. RANDOLPH, *Editor* June, 1948

Renaissance—1948

Beginning with its May issue, we welcome the return of the *Scientific American* to its traditional place in the world as a magazine for people who take a responsible interest in science. We have long felt the lack of such a magazine.

Before 1920 the *Scientific American* was a weekly with a monthly supplement, having the same page size as *Saturday Evening Post* and *Life*. Its news coverage was comparable to *Science News Letter*. Its articles were well written and well illustrated, by the standards of its day. They were very helpful to a young man trying to obtain a broad understanding of science as a whole, and to the scientific specialist trying to see how other fields of science would affect his specialty. The magazine was prosperous, and ultimately put up a building of its own, which it still occupies.

But as the literary "dark ages" of the twenties and thirties set in, it gradually decreased in size and quality, until a year ago it seemed about to fade out as many of its contemporaries had done. Its pages were few, its contents uninteresting, its editors old and tired.

Now we are watching its renaissance, with new owners, fresh capital, and competent young editors, meeting the needs of today as it met the needs of the past. Its articles are interesting, and well supplied with references for those who want to go deeper into the subjects. They have the expert illustrating we have long enjoyed in *Life*, from which some of its editors came. The pictures enable us to get the gist of the story if we have not time to read, and to find it later if we have forgotten the title, author, and date of what we want.

The *Scientific American* was not alone in its dark ages, nor is it alone in its renaissance. Both are signs of the times. What happened is that the class distinctions of the past century became obsolete. Machinery made the old proletariat unnecessary. Stocks and bonds made family fortunes unnecessary. Sex equality removed the need for those big homes woman's place was in. And as the sons of the slums and the sons of the wealthy suburbs merged to form our present classless society there came a time in the early twenties when a sudden economic slippage, a rapid readjustment, occurred.

The sons of the slums had more money than before. They had cars. They could afford to buy magazines. But they still had the literary taste a Spaniard would describe as "bread and bulls," implying a desire for food

without effort and thrills without risk. Magazines prospered if they catered to that taste. It has taken a younger generation to see the mess their fathers have made of the world, and the urgent necessity for taking a responsible interest if the world is not to become still worse.

Sons of the suburbs, meanwhile, were going through a generation of self-pity because they could no longer live as well as their parents lived. They felt they couldn't afford magazines. Ten years ago the reading public for magazines comparable to this new *Scientific American* would have been confined to that tiny minority who were taking a responsible interest in the approach of World War II. Other suburbanites felt too poor.

Now World War II has come and gone, and another readjustment has occurred. It is not so much that responsible people are richer than before. It is mainly that we have learned to be content with what we can afford. And so we are buying magazines that conform to our tastes, and are paying what they are worth. As time goes on we will see more such magazines on the market, and a decline of the bread and bulls literature which dominates the newsstands today.

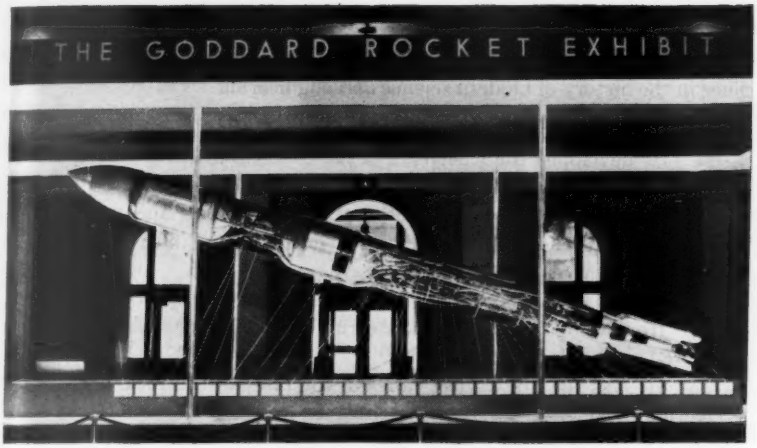
Science Fiction

On another page we publish a letter from one of our readers voicing a widespread complaint against the prevailing character of science fiction. This reader says, and many others agree with him, that science fiction loses a lot of reader interest because it is so completely careless in its scientific background.

At the same time, this field of literature is so rigidly conventional in its attitudes toward life in general that we have almost suspected it of following a party line. We are currently investigating this suspicion, but the results so far have been negative. What seems to have happened is that science fiction, being a new field of literature, has been more completely dominated than others by the bread and bulls literary trends of the past thirty years. It has no classics with which new writers can be compared, so the irresponsible writers have had the field to themselves.

We hope it will share in today's renaissance, for it has an important job to do, and it has not been doing it. The writer of fiction can do what the writer of articles can not. He can picture new inventions in a living world, with live people using them and being affected by them. He can bring out their social implications, which are often profound, and by doing so he can help the engineers to anticipate the "bugs" that so often develop in new machines when they move out of the laboratory and the proving ground to take their places in a real world.

The world is paying a very heavy price today because this job has not been taken seriously.



TWENTY-TWO FOOT GODDARD ROCKET. LABELS TELL WHAT THE PARTS ARE. SMALLER ROCKETS ARE IN THE GLASS-COVERED CASES

ROBERT H. GODDARD—FATHER OF MODERN ROCKETRY[1]

By Lieut. Gen. J. H. Doolittle, Retired

Vice-President, Shell Union Oil Corporation, New York, N. Y.

IT IS a privilege to have this opportunity to say a few words about the life and work of Robert H. Goddard, in whose honor we are here this afternoon.

Unfortunately for me, I did not become acquainted with Dr. Goddard until he was well along in his career. When I met him he was absorbed in rocket development and I was invited to witness some of his experiments in New Mexico.

Dr. Goddard, the pioneer inventor and developer of rockets, was one of the most remarkable men in the history of modern technology. Founder of a whole new field of engineering, he fathered the basic research and development which led to the great expansion of rocket activity in World War II, and which we may presume will give us the long-range controlled air weapons of the future.

Like many other men of vision who have made valuable contributions to fundamental and developmental research, Dr. Goddard and his important work were relatively little known during his lifetime. In the course of Dr.

[1] Speech given at official opening of the Goddard Rocket Exhibit, American Museum of Natural History, New York, N. Y., April 21, 1948.

Goddard's pioneering investigations, he achieved many "firsts" in rocket research, any one of which would be sufficient to assure him a permanent place in the history of modern science and engineering.

Among the principal ones recounted to me are:

1 He developed the basic idea of the bazooka in 1918, during World War I. The weapon was not used until World War II.

2 He developed a rocket motor using liquid fuels and used it in a liquid-fuel propelled rocket in 1926, antedating its use in the German V-2 by nearly 18 years.

3 He was the first to shoot a rocket faster than the speed of sound.

4 He developed a gyroscopic steering apparatus for rockets ten years before the Germans did it.

5 He was the first to use vanes in the blast of the rocket motor for steering rockets.

6 He patented the idea of "step-rockets."

7 He developed the mathematical theory of rocket propulsion and rocket flight, on which all modern military and experimental calculations are based.

8 He first proved, both mathematically and by actual test, that a rocket will work in a vacuum; that it needs no air or other substance to push against.

Educated in Massachusetts

The life of Robert H. Goddard typically follows the pattern of many Americans who have combined, often through force of circumstances, great scientific endeavor with an academic career. He was born in Worcester, Mass., on Oct. 5, 1882, received his early schooling in Boston, and then attended Worcester Polytechnic Institute.

Upon graduation in 1908, he stayed on at his Alma Mater as an instructor in physics. His professional career was conventional, rising from instructor to assistant professor, and finally becoming a full professor at Clark University, Worcester, Mass. Except for occasional leaves of absence, he continued professional pursuits until 1943.

As a young professor of physics, Dr. Goddard made important scientific contributions. During a brief research fellowship at Princeton in 1912–1913, he made the initial computations which later formed the basis of the Smithsonian paper of 1919. This is one of the two famous papers in which he provided the foundation for present-day developments in jet propulsion and rocketry. These calculations clearly indicated to him that rocket power would require only a relatively little fuel to lift a payload to great heights, provided a rocket could be constructed which would make effective use of the fuel.

Returning to Clark in 1914, he started in earnest to translate his theory

into practicality, beginning with ship rockets, and continuing with rockets of various types designed and manufactured by himself. Two years later he reached the practical limit of what he could do on his own resources. Fortunately, the significance of his work was recognized by a few farsighted persons who were able to provide the financial aid necessary for the continuation of his experiments. This vital help and encouragement came from the Smithsonian Institution, and later from Daniel Guggenheim and The Daniel and Florence Guggenheim Foundation.

Assisted by His Wife

Many a great man owes much of his success to the loyalty, understanding, devotion, and encouragement of a woman who is vitally interested in his career. These fine qualities were brought into Dr. Goddard's life by Esther Kisk, whom he married in 1924. She took an active interest in his experiments and served as the official photographer of his tests. MRS. Goddard is now engaged in editing Dr. Goddard's experimental notes for publication. We are fortunate to have her with us today.

When the United States entered the first World War, Dr. Goddard volunteered his services, and was given the task of exploring the military possibilities of rockets. He succeeded in developing a trajectory rocket which fired intermittently, the charges being injected into the combustion chamber by a method similar to that of the repeating rifle. He also developed several types of projectile rockets intended to be fired from a launching tube held in the hands and steadied by two short legs—much like the "Bazooka" of World War II.

These weapons were demonstrated quite successfully at the Aberdeen Proving Grounds on Nov. 10, 1918, before representatives of our Armed Services. However, the Armistice on the following day put an end to the war and also to immediate interest in these weapons.

Reports Establish Value of Rockets

His research and experiments during the next two decades were summarized in two papers, "A Method of Reaching Extreme Altitudes," and "Liquid-Propellant Rocket Development." These two famous reports did much to establish on a world-wide basis the scientific and engineering values in rocket and jet-propulsion research.

In the Second World War, Dr. Goddard again volunteered his services, and was engaged in liquid-fuel rocket research for military purposes at the time of his death.

Dr. Goddard lived to see the fruition of some of his youthful dreams. Rocket propulsion matured during his lifetime from a fantastic notion into an effective force for driving instruments of war. Continued research and development on rocket propulsion is not only necessary to peacetime scien-

tific progress, but is of vital interest to our national security and our ability to help maintain a decent world peace. I am most happy to hear Harry Guggenheim say that The Daniel and Florence Guggenheim Foundation expects to continue to sponsor this important work.

Before World War II, research such as Dr. Goddard's was little recognized or valued in this country. Our own military people saw very little promise in it. However, other nations did. The Germans carefully followed the progress of Dr. Goddard's work. They obtained copies of all the patents, and kept track of the progress being made at his research laboratory in New Mexico through the published accounts of his experiments.

Germans Benefited from His Work

It would be foolish to maintain that the Germans merely copied Dr. Goddard's work. We know that they lavished money, brains, man-hours, and materials on their own research and development. But it is no mere coincidence that there is a striking similarity between the German V-2 rockets and the large pump-rocket in the Goddard Exhibit here. That similarity does not end only in the outward appearance and in the main structure and the tank and motor design; it continues even to the smaller details of tubing, pump construction, and guiding devices.

Dr. Goddard's rockets were being flown successfully in New Mexico while the Germans were just beginning their rocket work on the shores of the Baltic. In that fact lies a tragic lesson. Too many of us look backward rather than forward. Too often military people are prone to prepare for the next possible war in terms of the last one, resisting progress and changes in basic concepts until cruel reality forces them to accept the new.

We had in this country before the war the most know-how and the leading developments in the field of rockets. We neglected them until our enemies demonstrated their value. Had the Germans been able to accelerate their rocket program and to employ them earlier, the whole course of the war might have been changed. If not, victory would have been much more costly in money, materials, and precious American lives.

Today, thanks to a stepped-up program of research and development, the co-ordination of thousands of trained technical men in many fields, and the expenditure of millions, we have regained our position of leadership. We must keep it. We cannot afford to lose out in the race for supremacy in the field of rocket propulsion or in any scientific endeavor which involves our national security.

Guided Missile Warfare

There are two schools of thought on the future of guided missile warfare. The first claims that "push-button" warfare is just around the corner—and that the corner is not many paces away. The second asserts that the military use of guided missiles is something to be reckoned with in the far dis-

tant future—and that it is the bogey man of war-mongers and the purveyors of fear.

I disagree with both schools. Neither is correct.

I disagree with both chiefly because they represent fundamental concepts which, in my opinion, are fallacious and which are dangerous to our national security. The first would have us abandon our present military establishment and place our faith in weapons of offense and defense which are not yet perfected. This we cannot do in our present troubled world, any more than you can afford to let your insurance policies lapse today because you may be able to buy better ones five or ten years from now.

The second represents the traditional, hidebound, status-quo group who accept progress only when it is impossible to resist it further, a group which reflects the kind of unthinking mentality which failed to perceive the significance of the work of Dr. Goddard and other pioneering scientists. World War II and all the wars which preceded it have proved the fatal folly of trying to fight the next war with the weapons and concepts of the last.

Our proper course lies between the two extremes. We must retain present useful weapons until new and better ones are perfected—and then periodically replace the outmoded ones with the new. Modernization must be a continuing process so we will always have in being, the most modern military establishment economically possible today and be actively developing more modern equipment for tomorrow. To do otherwise is to gamble with our freedom and with the peace of the world.

Two major problems must be solved before guided missiles can become effective and economical weapons. First, they must have sufficient range to reach all key objectives in any enemy land—say 3000 miles. Second, they must have an extremely accurate directing and control system which will allow them to be guided from launching to the exact desired point of impact. The solution of these problems will take extensive research in many fields of human knowledge, and may take years. The speed with which these and other rocket problems are solved depends upon the pace and magnitude of our research and development work. That, in turn, depends to a large extent upon the urgency of the moment and upon the vision of our leaders

However, I am certain that out of our scientific endeavor will come new weapons—guided missiles which will have atomic warheads and which most likely will employ atomic energy as a propellant; new weapons which will assure our ability to defend ourselves and to help maintain a decent peace until the establishment of a legalized world organization in which all nations can live without fear and in understanding and concord with their neighbors.

In addition to their military potentialities, rockets offer interesting prospects for future commercial development. Rocket engines capable of driving rocket craft at speeds in excess of 3000 mph already exist. Craft which can carry passengers at such speeds are still undeveloped, but sometime in

AT THE OPENING OF THE ROBERT H. GODDARD ROCKET EXHIBIT IN NEW YORK
(Left to right): Gen. J. H. Doolittle; Dr. Albert E. Parr, director of The American Museum of Natural History; Mrs. Robert H. Goddard; Harry F. Guggenheim, president of The Daniel and Florence Guggenheim Foundation; Mrs. Roger W. Straus, vice-president of the Foundation, and Col. Charles E. Lindbergh.

the future it may be possible for rocket-aircraft passengers to fly from New York to Europe in an hour, or to Buenos Aires in two hours.

Such flights, according to rocket engineers, may be only the beginning of possible speeds or distances. Some day we may be able to leave the earth entirely and fly to the moon, or even to a nearby planet, or set up an artificial orbit around the earth from which we can patrol the earth or carry on scientific research in space. Such dreams and ideas sound like pure fantasy; however, each advance in rocket research—brings them closer to reality.

It is interesting to note that about 25 per cent of the leading rocket engineers questioned recently by The Daniel and Florence Guggenheim Foundation predicted that flight into space might occur in the next ten years. I put it considerably further away than that, but I am confident that this new form of power, pioneered by Dr. Goddard, may ultimately permit some adventurous men to explore beyond the boundaries of earth's atmosphere. It could happen within the lifetime of some of us here this afternoon.

Whether these things do come to pass within our lifetime is not of paramount importance. The important thing is that here in America there must be an agressive continuation of fundamental research, and proper recognition, encouragement, and aid must be given to scientists like Dr. Goddard—men who in the face of disbelief, ridicule, and great technical difficulties, persist with courage and determination until they achieve their goals. For in the fruits of their scientific and spiritual labors lies the true fulfillment of our dreams and hopes for social, economic, and scientific progress and for a peaceful and a better world.

HONORS TO DR. GODDARD

A DISTINGUISHED group of 350 scientists, educators, and industrial leaders met at The American Museum of Natural History on April 21 to honor The memory of Robert Hutchins Goddard, founder of the modern field of rockets and jet propulsion. The occasion was the opening of the first public exhibit of his rockets, in the south foyer of the Museum's old main building.

Central feature of the exhibit is one of Dr. Goddard's largest rockets, 22 ft long, with part of its casing cut away to show the interior construction. Around it is a collection of smaller rockets, and a series of panels outlining the scientific principles on which rockets operate.

The exhibit, sponsored by The Daniel and Florence Guggenheim Foundation which financed much of Dr. Goddard's work, will remain at the Museum until some time in July. It will then take to the road, visiting other parts of the country and giving as many people as possible a chance to see it.

Ceremonies were opened by Albert E. Parr, director of the Museum. The exhibit was unveiled by Mrs. Esther Kisk Goddard, wife of the inventor, and for many years his secretary and photographic assistant. Dr. Goddard died on August 10, 1945.

Addressing the gathering, Harry F. Guggenheim, president of the Foundation, told of the Foundation's survey of the present needs and future possibilities of rockets and jet propulsion, as seen by leading research engineers, manufacturers, educators, and government officials.

"The survey," he said, "included questions on what the field will develop in the near future, what the field's most pressing needs are at present, what are peacetime applications of rockets and jet propulsion.

"'A summary of the results of the survey is available, and copies have already been handed to you. But I think it is important to point out here some facts about what these men think of the future of rockets and jet propulsion.

Commercial Supersonic Flight Expected

"One of the questions asked was as to the progress expected within the next ten years. At least two thirds replied that they believed aircraft, even commercial aircraft, would be flying at speeds greater than the speed of sound—740 mph at sea level—within that time.

"Over one fourth said they expected definite progress within ten years toward the development of rockets capable of interplanetary flight.

"Almost all were unanimous in their prediction that within ten years new, improved motors and propellants will be developed, making these accomplishments possible.

"One of the great needs expressed by those questioned is for better-trained people to take up the many engineering, scientific, and technical problems connected with the future development of rockets. Five years from now, they declared, the need for trained men will probably be just as great, if not greater, than now, and the requirements even more severe as to basic training. It was pointed out by a number that there are only two or three universities in the country today where such training can be obtained.

"The third item on the Foundation's agenda is the encouragement of a peacetime industry in rockets and jet propulsion. Leading men now in the field were asked whether they foresaw this possibility.

"The majority—83 per cent—said they definitely did. These men predicted that in the future we will see military, commercial, and even private aircraft powered by jet engines. They predicted widespread use of jet-assisted take-off, the launching of gliders by rocket power, and the use of rockets as airbrakes for fast airplanes.

Rocket Mail Predicted

"They also predicted that the use of rocket power would transport mail and light cargo at supersonic speeds; carry scientific instruments into the upper atmosphere for meteorological studies; brake trains; dock ships. It was their further prediction that many unforeseeable industrial applications for rocket power will be found, particularly where large amounts of power are needed for periods of relatively short duration."

Concerning the Foundation's part in furthering Dr. Goddard's work, and its plans for future assistance in this field, he said, "My father, Daniel Guggenheim, learning of Goddard's experiment through Col. Charles Lindbergh, who was a trustee of our Aeronautical Foundation, determined to provide financial support for further research.

"An arrangement was made which enabled Dr. Goddard to carry on his work under adequate circumstances. After studying the possibilities of various sites, he moved his laboratory and testing ground to New Mexico. There, on a ranch near Roswell, he continued the experiments which culminated in the development of rockets like those in this exhibit.

"The Foundation has taken, as a principal objective for its future work with rockets, the development of peacetime uses, and the encouragement of a peacetime industry in this field. Several projects toward this end, which we believe will be of far-reaching importance, are now under study by the Foundation, and will be announced in due course. In this program we are planning to aid rocket development on three broad fronts:

1 Making available to those who need it the technical and general information which Dr. Goddard accumulated in his lifelong research in this field. This includes publication of some of the voluminous technical data from his notebooks; the administration of more than 150 patents

and patent applications in a way to benefit most the rocket and jet-propulsion industry, and the presentation of some of Dr. Goddard's actual rocket material for study, as in the present exhibit.

2 The development of ways to aid in the education and training of new leaders and specialists.

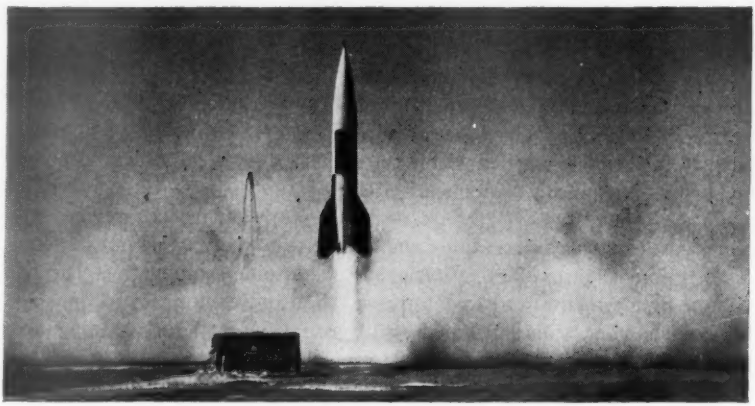
3 Study of possible peacetime uses for rockets and jet propulsion, and stimulation of research and development along these lines.

"We have made some progress on the first of these fronts: Dr. Goddard's works are now more widely available to technical people and the public. Later this spring the first volume of Dr. Goddard's technical notes, under the title, 'The Goddard Rocket Experiments, 1929 to 1940,' will be published by Prentice Hall, Inc. We hope that more of Dr. Goddard's technical material also can be published in the near future. His work is still, in many respects, far ahead of current developments in rocket thought and will be an invaluable source of information for rocket engineers.

"If our existence is to depend on the atom bomb and push-button warfare, then our best preparation will be in a peacetime nuclear-energy industry and the peacetime application of jet propulsion and rockets. In other words, let us build push-button industry.

"The Daniel Guggenheim Fund for the Promotion of Aeronautics in some slight measure contributed after World War I to the commercial aviation development in the United States. It was this commercial aviation development that was the basis for our supremacy in the air in World War II.

"It will be the endeavor of The Daniel and Florence Guggenheim Foundation to contribute in some measure to the development of the peacetime application of jet propulsion and the rocket."



V-2 LEAVING THE GROUND AFTER BEING IGNITED AT THE U. S. ORDNANCE PROVING GROUND, WHITE SANDS, N. M.

THE PIONEER ROCKET PROJECT OF THE U. S. NAVY

By Lieut. Comdr. R. C. Truax

Member ARS, Bureau of Aeronautics, U. S. Navy Department, Washington, D. C.

A brief nontechnical review of the history of the first liquid-propellant rocket-development project ever to be sponsored by the U. S. Army. A summary of the important contributions of the jet-propulsion project located at the U. S. Naval Engineering Experiment Station is presented for the first time. The development of liquid-propellant rocket units for assisted take-off of seaplanes and for the propulsion of guided missiles is discussed.

THE STORY of liquid-propellant rocket development in the Navy is closely linked with the history of Project 3401, or, to give its full title: Project TED EES 3401. This project was established at the U. S. Naval Engineering Experiment Station by the Bureau of Aeronautics in July, 1941. The primary objective was the development of a rocket unit to assist the take-off of large flying boats. Specifically, it was desired to increase the carrying capacity of the PBY-2 airplanes and reduce the length of the take-off run.

First personnel assigned to the project included the author as officer in charge, Ensign R. C. Stiff, Ensign J. F. Pattan, Ensign W. Schubert, and Robertson Youngquist. Preliminary analysis of the problem indicated that a thrust of approximately 3000 pounds for a period of about 35 seconds would be required. Very early in the course of development, the major design characteristics were selected. For logistics reasons the propellants chosen were red fuming nitric acid as oxidizer, and gasoline as fuel. The burning time required dictated the use of a regeneratively cooled motor, and the simplicity and reliability desired indicated that a compressed gas-propellant feeding system would probably be the most desirable. In regard to the latter point, the advantages of generating the pressurizing gases from chemicals carried within the rocket were recognized and development work on suitable systems initiated.

Since at that time design data on liquid-propellant rocket engines was almost nonexistent, a program of small-scale tests was carried out to determine injector (atomizer) criteria, to determine combustion-chamber volume requirements, and to determine the heat-transfer rate to the combustion-chamber walls. Studied also were means for igniting and maintaining combustion with the selected propellants.

In order to arrive at an optimum injector design without introducing additional complications the program called for open-air tests of various injector configurations. This procedure spread consternation among the

project personnel when tests disclosed that the combination of nitric acid and gasoline could not be ignited, even with a blowtorch, and that combustion could be obtained only after the propellants had run together on the ground and remained there with the gasoline burning in air for some time. After numerous failures we were ready to abandon the propellant combination when it was suggested that high pressure and confinement might be prerequisites for proper combustion. With this thought in mind, the decision was made to "take the bull by the horns" and try a full-pressure test of a complete rocket motor. The test was a complete success and excellent combustion was obtained. All further tests were made with the injectors installed in suitable test motors. However, since enclosing the injector in a motor prevented visual observation of the initial-flame pattern, and thus comparing reaction volumes, a new method of evaulating injector designs became necessary. A suitable criterion was set up by Mr. Youngquist, the parameter, Ap/w, now almost universally called c. This parameter is the area of the nozzle throat multiplied by the combustion-chamber pressure and divided by the mass rate of flow of propellants. It is numerically equal to the velocity of the gases at the throat and is an indication of the gas temperature in the combustion chamber and hence the combustion efficiency of the injector when used with a given chamber.

War was declared shortly after the first successful small-scale test and under renewed pressure the staff and budget of the project were rapidly expanded. The experimental program was accelerated accordingly. In late spring of 1942, design of the full-size motor was started. Since two units were to be used to give the 3000-lb. thrust, each motor was required to deliver 1500-lb thrust. The 1500-lb motor constructed was the largest built in the United States up to that time. The first firing took place in June. A lag in ignition by the powder-squib igniter permitted a dangerous quantity of propellants to accumulate in the chamber. The result was an explosion that destroyed the entire stand.

Acid-Aniline Rocket

While the motor program had been proceeding, Ensign Stiff, in charge of the chemical gas-generator program, had discovered that several chemicals ignite spontaneously with nitric acid; among these, aniline was considered the most practical. This information was communicated to the rocket group at the California Institute of Technology, which was working on a similar program for the Air Corps. Although ignition was readily effected in small-scale tests by pyrotechnic means, ignition of larger-scale motors was more difficult, and ignition lag usually meant a disastrous explosion. In the search for an alternate method, this group proceeded to use aniline in place of gasoline as the fuel and with excellent success. In spite of the logistic arguments against its use, pressure of time forced the Project also to turn to aniline for a solution to the problem of ignition.

The second full-size motor using aniline as fuel was successful, and was used with only minor refinements in the final unit. This unit was designated the DU-1 (droppable unit number one) for it was designed to be dropped by parachute after use. It was rated at 1500-lb thrust for 35 seconds. Weight empty was about 325 lb and loaded about 655 lb. Two units were used, one suspended from the wing struts on either side. Take-off tests were conducted in the spring of 1943 and were completed without incident. The average reduction in take-off distance was 60 per cent. Production of rocket units of this general type was given over to civilian concerns and the Project turned its development efforts along other lines.

The flight test crew of the Project found no lack of work to do. Very early in the history of the organization, Dr. R. H. Goddard offered his services to the Navy and was awarded a contract to develop an assisted-take-off unit based on liquid-oxygen and gasoline propellants. Dr Goddard brought his group from New Mexico, where he had been working for several years under the sponsorship of the Guggenheim Foundation, and set up shop at Annapolis alongside the Navy Project. His unit was the first to be pronounced ready for flight tests and it was accordingly installed in the PBY-2. This unit was not designed to be dropped but was built into the afterend of the airplane. Bad luck dogged the footsteps of Dr. Goddard and after a fire that severely damaged the airplane further flight tests were discontinued.

After the DU-1 tests, a new airplane arrived, a Martin PBM, and into this was built a JATO unit (as they came to be called) built by Reaction Motors, Inc., Pompton Plains, N. J. This installation delivered 3000-lb thrust for 60 seconds using liquid oxygen, gasoline, and water as propellants. Tests with this unit were highly successful.

The Aerojet 38LDW1500, the granddaughter of the DU-1, was the next liquid JATO to be tested by the Project flight-test crew, under the supervision of Captain W. L. Gore, USMC, chief test pilot. This unit performed very well. Approximately 100 units were built. Of all the liquid-propellant JATO units developed the 38ALDW1500 came the nearest to service use. It was used to a considerable extent by the U. S. Coast Guard Station at San Diego, Calif., for off-shore rescue work.

Solid-Propellant JATO

For service use from advanced bases during the war the solid-propellant JATO was deemed preferable to the liquid-propellant type. Superior logistics and less weight per unit outweighed the advantages of cheaper operation and repeated use. The solid-propellant JATO was a development primarily of the Jet Propulsion Laboratory at the California Institute of Technology and the Aerojet Engineering Corporation. All of the early Navy flight tests of these units were performed by the Engineering Experi-

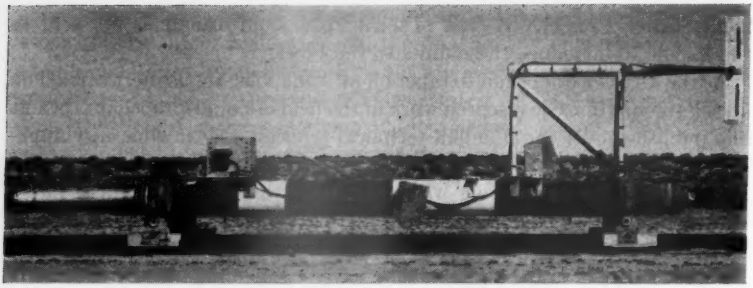
ment Station Project. A crew of technicians from Annapolis was sent to the Pacific to introduce these units to the Fleet.

As the JATO work began to taper off at Annapolis, the Project carried on a vast amount of basic research work in the field of liquid-propellant rockets and published over one hundred technical reports. Meanwhile new applications were arising. News came to the group at Annapolis that the Naval Aircraft Factory was toying with the idea of using a small, fast, radio-controlled airplane to carry an explosive charge that would destroy enemy bombers. The power plant for this missile was to be a small turbojet but the engineers at the aircraft factory were rather appalled by the cost of this engine for an expendable airplane. As a result the Experiment Station Project was called upon to design a rocket engine delivering 350-lb thrust for a period of about two minutes. This power plant was developed in the short space of 45 days primarily through the intensive efforts of the project engineer, Lieut. William Schubert. Test flights of the Gorgon (as the missile was called) were successful as far as stable flights were concerned. The rocket engine drove the Gorgon to speeds in excess of 500 mph, an unheard-of speed for the time. The Gorgon power plant was the forerunner of the engine that powers a present-day missile that cannot yet be discussed publicly. Propellants used were mixed nitric-sulfuric acids and monoethylaniline.

With the surrender of Germany, the Project was subjected to increasing pressure from the local citizenry who objected to the noise and fumes created by the rocket tests. In view of these objections and the fact that rocketry, in the course of the history of Project 3401 had "come of age," it was decided to seek a new more permanent home for the activity. After considerable investigation of sites and organizational tie-ins, the Project in December, 1945, was moved to the Pacific coast to become the nucleus of the Propulsion Laboratory for the newly formed Naval Air Missiles Test Center at Point Muga, Calif.

Feathers in Our Caps

THE Indian style of fighting resembled modern war and modern industry in that the chief often wanted to know in a hurry which of the men available could be depended on to perform certain duties. The feathers in their war bonnets told him this. Each feather had been awarded for some act of service or heroism beyond the call of duty, and the markings on each told the character of the deed by which it had been earned. He could pick at a glance the experienced warrior whose many feathers proved his wisdom as well as his courage. He could pick the ambitious youth, with a few feathers and the desire to earn more, and he could spot the unfeathered man who had best be kept in the ranks. Writing for the JOURNAL is one way for a modern warrior to get a feather in his cap.



NORTHROP ROCKET ON THE RAILS READY FOR FIRING

ROCKETS ON RAILS

DURING the past few years two experiments have been undertaken with the running of rocket-driven vehicles on rails. One of these was at Muroc Air Base; the other at Inyokern, both in California. At Muroc Air Base a standard-gage railroad of standard construction was used. At Inyokern a track of special design was built. At both places the rockets were carried and held to the track by runners, wheels being impractical at the high speeds attained.

The immediate objective of both experiments was to provide supersonic wind-tunnel data without the expense of a supersonic wind tunnel. But the experience gained can be valuable when it comes to launching large high-speed rockets, as anyone can realize who has watched a V-2 rocket stand on its tail during its leisurely take-off. At the very time when its weight is greatest the V-2 is fighting gravity rather than gaining speed, and this is the waste that starting on rails prevents.

The rocket sleds used at Muroc Air Base were built by Northrop Aircraft, Inc., Hawthorne, Calif. They were crude affairs, as the photographs show, being merely aluminum frames with slippers of magnesium and stainless steel, and powered by large war-surplus rockets of several sizes. No attempt at streamlining was made.

For the test runs a small model airfoil was mounted on a boom, stretching in front of the rocket sled, and instruments were attached to record certain effects of the high-speed air on the model. The tests were set up on a 2000-ft railway, eight miles north of the north base at Muroc, on the edge of the reservation.

Equipped with rockets and ready to "roll," the high-speed sled weighed about 1500 lb, and measured 15 ft long. It was slung low, with its bulk rising only about 14 to 16 in. above the track. The boom, carrying the test airfoil, was mounted on a tubing structure protruding above the sled itself.

After four preliminary runs at slower speeds, the Northrop engineers,

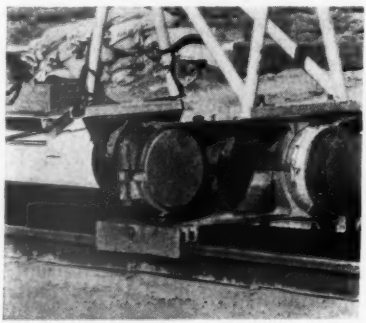
headed by S. E. Weaver, set up the first high-speed test, on Sept. 20, 1946. The carriage was considered expendable, and no effort was made to halt it after the top speed was reached. Every 50 ft along the track was a small switch, to be tripped by the carriage as it passed, transmitting an electric signal to be clocked against a timing device. At the same time a high-speed motion-picture camera recorded the run, calibrating the travel of the carriage against markers along the track.

With the carriage carefully checked out on the track by the desert test crew, the rockets were fired. The sled mounted almost instantly to a velocity of 1485 fps, or more than 1012 mph. Although the rockets were designed to burn less than 2 sec, they had barely flared out as the carriage roared off the end of the 2000-ft track and bounced across the flat expanse of desert.

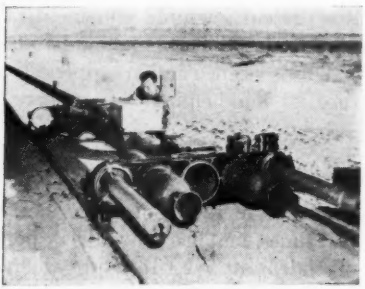
It had passed over the timing switches at such high speed that the timing switches failed to function and the computations for the first run were made solely from the record of the high-speed camera. Subsequent accurate calibration of the camera-marker system corroborated these results and allowed the engineers to obtain precise speed data on each run.

Additional high-speed runs were made later, the sled again attaining a speed of 1485 fps. Then a series of slow-speed runs were made to check lateral and vertical acceleration. On March 7, 1947, the fastest run of the program was recorded when the sled under the thrust of the rockets attained a speed of 1019 mph.

Since the short track at Muroc did not permit the engineers to halt the sleds after reaching their high speeds, no serious effort was made to obtain aerodynamic readings from the model airfoils. Enough was learned through cameras mounted on the carriage and through instruments on the airfoils to determine that a 10,000-ft track, with proper braking facilities, would make it possible to reach the 1000-mph clip and then halt the carriage before reaching the end of the track.



CHECKING INSTRUMENTS ON THE SLOW-SPEED ROCKET



SLIPPER OF THE NORTHROP RAIL ROCKET

One method used for braking the high-speed sled was a water trough, mounted in the roadbed between the rails. A 3-in. diam spout dipped into the trough, picking up quantities of the water and deflecting it through 90 deg by means of curved channels. This exerts a powerful braking effect.

The Muroc track is laid so straight and true that variations in it cannot be seen by the naked eye. But at 1000 mph it was quickly found that even this smooth track was a rough road, so springs made of synthetic rubber and mounted between metal plates were used with excellent results. The engineers observed the action of the slippers at high speeds by means of a high-speed camera fitted to the sled.

SUBMARINE WITH GUIDED MISSILES

STRATEGIC use of a submarine equipped with guided missiles having atomic warheads is interestingly described by Alec Hudson in his story "Attack" in the June 5 issue of the *Saturday Evening Post.* The story begins with the discovery of a base on an Arctic island for launching a bacteriological attack against the United States, and the countermeasure decided is to send a submarine to cruise on snorkel while awaiting the signal, and then attack the island with atom bombs.

The author seems to have pretty sound ideas of what his equipment can and cannot do, and his use of fiction as a medium permits him to bring in a lot of side problems and human reactions which the writer of an article generally has to leave out. His officers are well aware of the need for precision even when using atom bombs, and their boredom with the long wait, their tenseness in attack are very well described. The story also brings home, as through the eyes of a spectator, the fact that jet planes are too fast for submarine hunting. An old-fashioned prop plane proves more dangerous.

Also well brought out is the fact that we cannot have peace in the world as long as we have a great power whose subjects have been taught all their lives that another great power should be destroyed. We can have only this present scientific armament race, in which sudden disaster can come from letting the other fellow get ahead of you.

This is science fiction at its best, adhering to known facts and reasonable theories, and helping us to prepare for what may happen tomorrow.

J. R. R.

THE lecture on space travel which was given by Major James R. Randolph at the September meeting last year has been repeated several times, and has proved very popular. It has been given to four groups of students at Pratt Institute, where Major Randolph teaches, to the annual meeting of the Pratt Engineering Alumni, and to several meetings of the Reserve Officers Association. It is now illustrated with lantern slides.

GE OPENS TEST FACILITIES FOR JET-PROPELLED HELICOPTERS

ESTABLISHMENT of new facilities at Schenectady, N. Y., for the development and testing of component parts of proposed jet-propelled helicopters, as a part of a long-range program in the development of revolutionary aircraft for the U. S. Air Force, has been announced by the General Electric Company.

The new project, which greatly expands the company's activities at the GE Flight Test Center at the County Airport near Schenectady, has been under way for more than a year, according to David C. Prince, vice-president in charge of the GE General Engineering and Consulting Laboratory.

The new facilities, adjacent to the company's large hangar-laboratory, are "a further expansion of our aircraft-equipment development and flight testing program," Mr. Prince said. He explained that the two-year-old Flight Test Center was established to enable company engineers to "carry out aircraft developments under the severities of flight conditions" and that the program to date has included the flight testing of jet engines, turbosuperchargers, automatic pilots, a flight recorder, radar, and other aircraft instruments and equipment. The new division is working on new-type jet power plants for helicopters and other component parts for the rotary-wing aircraft.

Outdoor Bowl-Shaped Pit Used

Operated by the Thermal Power Systems Division, under the direct charge of J. K. Salisbury, Mem. ASME, GE project engineer, these new facilities include:

An outdoor bowl-shaped pit, 150 ft in diameter and 13 ft deep, with propelling mechanism for the testing of jet units located at the tips of the whirling helicopter blade; an all-steel structure, 40 by 80 ft, which is used for laboratory and workshop activities, and also includes control and instrument facilities for the propelling mechanism.

A special observation room, adjoining the pit, has concrete walls 3 ft thick to safeguard engineers during the testing of the rapidly whirling jet-helicopter blade, it was explained.

Believed to be the first of its kind and unique in design and size, the jet-helicopter development section was constructed at a cost of more than $100,000, not including special equipment loaned to the company for the project by the Air Force.

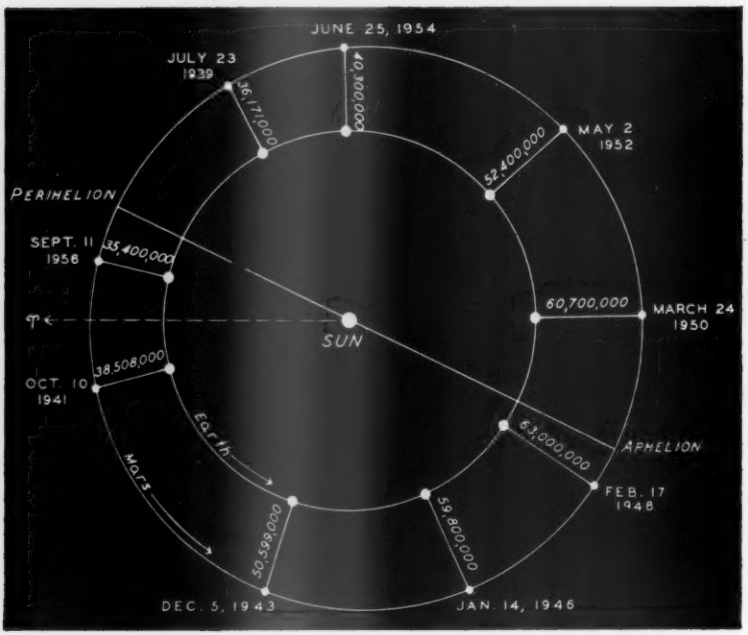
Government-owned equipment being used includes Diesel generators, superchargers, and Army tank engines, which drive the superchargers to produce air for the jet burners.

The development program is a two-phase one, Mr. Salisbury said. The first or preliminary part of the project, he explained, is a study phase, cover-

ing evaluation, performance, and design of various types of power plants, and aerodynamic testing of critical components. This included the static testing of burners—various types of jet-propelled tips—to determine which type would be the most satisfactory. Burner units determined to be the best type to date then were designed and built by the company.

The second phase of the long-range program is the power testing of the burners, which use kerosene fuel, in the outdoor test pit. In addition, the prototype jet engines to be used as a helicopter power plant will be erected and tested, supplying air to the whirl-test blade in the pit and simulating ultimate operating conditions.

A 1000-hp electric motor is used to drive the blade when the jet-driven tip is not fired in order to study drag of the test setup prior to "firing up" the burners, Mr. Salisbury explained. When the burners are operating under their own power, the large motor is used as a generator to measure the thrust produced by the jets.



KEEPING TRACK OF MARS

Because the planet Mars has a year of 687 days while the earth's year is only 365, the two planets are close enough for good seeing only for short periods, at intervals of two years. The above chart, reprinted through the courtesy of *Sky and Telescope*, shows oppositions in the recent past and in the near future.

ISOTHERMAL EXPANSION IN NOZZLES

DESIGNERS of steam turbines, gas turbines, and rockets are accustomed to start with adiabatic expansion assumed as the ideal. Our theories are developed on the basis of this ideal, and corrections made to fit them to the imperfect reality. In this form of expansion the gas is fully heated before it enters the nozzle, and velocity is gained at the expense of this heat, without further heating in the nozzle.

The use of isothermal expansion, or of something approaching it, has rarely been considered. For in isothermal expansion there is no use made of the energy which is used in adiabatic expansion. It is put in just the same, and is carried through the nozzle and thrown away. More heat must be put in to give the increased velocity. The following equations will make this clear.

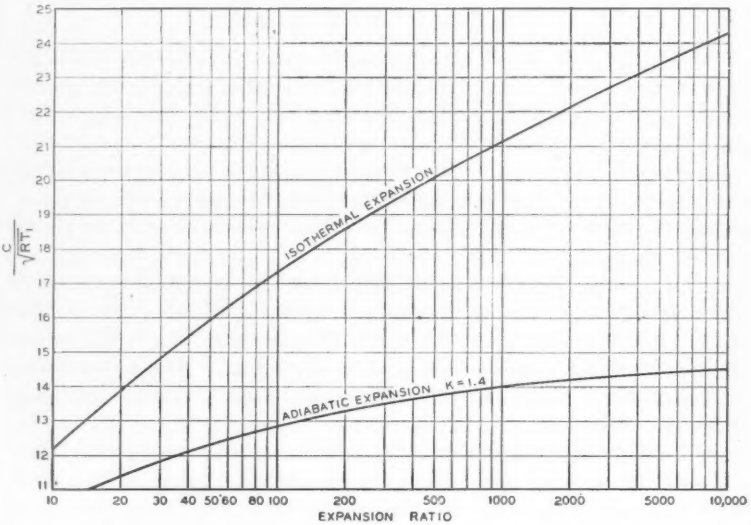
For adiabatic expansion

$$\frac{v_1^2}{2gJ} + h_1 = \frac{v_2^2}{2gJ} + h_2$$

For isothermal expansion

$$\frac{v_1^2}{2gJ} + h_1 = \frac{v_2^2}{2gJ} + h_2 + Q$$

In both these equations h_1 and h_2 are the enthalpies at the beginning and



COMPARISON OF ISOTHERMAL AND ADIABATIC EXPANSION

end of the expansion. In isothermal expansion they are equal. v_1 and v_2 are the velocities at the beginning and end of expansion, and $2gJ$ is the familiar conversion term for expressing kinetic energy in Btu. It is approximately 50,000. Q is the extra heat that must be added to produce velocity increase in isothermal expansion. It is equal to the change in kinetic energy.

The occasion for using isothermal expansion, or an approach to it, is that in rockets and gas turbines we are frequently limited by the temperature the metal parts will stand, and are compelled by this limit to start with a temperature much lower than we can get from our propellant. In adiabatic expansion the temperature goes down as the gas expands through the nozzle, so that if the combustion chamber is at the limiting temperature the exit of the nozzle is at a much lower temperature. We are interested therefore in seeing if we can gain anything by keeping the temperature up as the gas expands, using energy we would otherwise not be able to use although it is present and available.

For purposes of comparison the two equations for jet velocity c have been put in the following forms:

Adiabatic

$$c = \sqrt{RT_1}\,\sqrt{2g}\,\sqrt{\frac{k}{k-1}\left[1 - \left(\frac{P_2}{P_1}\right)^{(k-1)/k}\right]}$$

Isothermal

$$c = \sqrt{RT_1}\,\sqrt{2g}\,\sqrt{\log_e\left(\frac{P_2}{P_1}\right)}$$

In these equations P_2/P_1 is the expansion ratio, T_1 is the initial absolute temperature, k is the ratio of specific heats, g is 32.2, and R is the gas constant. It is approximately 1544 divided by the molecular weight of the gas. More exact values can be obtained from handbooks.

As R and T_1 will vary with the problem, the most convenient way to plot these equations for general use and comparison is to use the expansion ratio as one co-ordinate and $c/\sqrt{RT_1}$ as the other. This is done in the accompanying chart.

As an example of its use, let us suppose our working fluid is steam, for which $R = 1544/18 = 85.8$, and $T_1 = 4000$ R. Then $\sqrt{RT_1} = 585$. If, then, we have an expansion ratio of 500, the values of $c/\sqrt{RT_1}$ will be 13.7 for adiabatic expansion and 20.1 for isothermal. The corresponding jet velocities will be 8030 for adiabatic and 11,780 for isothermal expansion, which is a very substantial improvement. In order to secure this velocity it will be necessary to add 2740 Btu per lb in addition to the heat required to bring the working substance up to its initial temperature of 4000 R. As the enthalpy of steam at 4000 R is only 3000 Btu per lb, the sum of the two is just within the limit set by the heat of combustion of hydrogen and oxygen, and could probably be obtained.

The advantage of getting this higher velocity without a higher temperature is especially obvious in rockets, for which the mass ratio is $m = e^{v/c}$ for if in this equation we make $v = 26{,}500$ fps, which it would have to be for a satellite ship, we get a mass ratio of 27 with adiabatic expansion and only 9.5 when using isothermal expansion.

From the point of view of design also, isothermal expansion looks good. For it means a shorter combustion chamber and a coarser mixing, so that fuel and oxidizer enter the nozzle with combustion still incomplete, and combustion goes on all the way through the nozzle.

With atomic energy its use indicates a reactive substance which can be fed out into the stream of propellant and will give off its energy in the very small fraction of a second the propellant is in the nozzle.

To the student of thermodynamics, adiabatic expansion and isothermal expansion are both special cases of polytropic expansion, with $n = k$ and $n = 1$, respectively. Intermediate values of n are also possible, and these would result in curves on the chart between the two curves drawn. It is also possible to have values of n less than 1, in which case the temperature would rise as the gas expands. And it is obvious from the chart that such a process would be even better than isothermal expansion when it comes to reducing the mass ratio of a rocket. It would mean also that the highest temperature would be at the exit where the pressure is low instead of being in the combustion chamber. J. R. R.

Captain Gore Decorated

CAPT. William L. Gore, a member of the Board of Directors of the American Rocket Society, has been awarded the Distinguished Flying Cross for heroism and extraordinary achievement in connection with the jet propulsion and jet assisted take-off program of the Naval Bureau of Aeronautics.

Captain Gore enlisted in the Marine Corps in 1933, and served as enlisted pilot in all grades from corporal to warrant officer. He reported to the Bureau of Aeronautics in 1942, and was rapidly promoted. He is an expert pilot of all types of Navy aircraft, and is credited in the President's citation with "Skillfully performing practically all of the original flight testing of both solid and liquid propellant jet assisted take-off units." He assisted the Coast Guard in its adaptation of JATO to sea-rescue work, conducted the shipboard tests, and perfected patrol plane take-offs with JATO.

The presentation of the medal was made by Captain C. M. Bolster, of the U. S. Navy, who is Deputy and Assistant Chief of Naval Research. A letter of commendation from General A. A. Vandergrift was read, in addition to the President's citation. Captain Gore is now director of Government operations for Aerojet Engineering Corporation.

NEW LABORATORY FOR JET-ENGINE COMPONENTS

A $25,000,000 center at Lynn, Mass., for the development, testing, and production of aircraft jet engines has been announced by the General Electric Company.

Since the war's end, nearly $11,000,000 has been spent by the company for new facilities, including a huge new test laboratory for jet-engine components which has been in partial operation for several months.

Under construction for the past two years as part of the company's long-range expansion program in the jet-propulsion field, it is believed by engineers of GE's Aircraft Gas Turbine Divisions to be "the world's largest and most complete plant for the development of improved and larger size aircraft turbine power plants."

The new laboratory consists of stands for full-power testing of compressor, combustion chamber, and turbine elements of actual engines, and model testing of single and multistage compressor elements. Scale-model turbine elements and individual combustion chambers of multichamber engines are tested in older, existing facilities.

"The primary purpose in building such a complete development laboratory," said H. D. Kelsey, manager of the GE Aircraft Gas Turbine Divisions, "has been to make available to our engineers the information necessary to develop and produce jet engines of higher performance and greater capacity for given frame sizes, and even larger frame sizes, than heretofore has been possible." He explained that the entire expansion program from its start was planned and financed by the company.

"Our facilities have been more than doubled and our activities in the jet-propulsion field have steadily increased since the end of the war," he said. He pointed out that production figures, which, for security reasons, cannot be released, have been boosted greatly with the development of the TG-190 (Air Force J47), a jet engine of improved design and greater power than any of the three types previously developed and produced by the company.

The new engine, which has a rating of about 5000-lb thrust, has been in production at the Lynn (River Works) plant for the last several months. Future development of this engine promises to increase its rating to 6000 lb.

According to E. E. Stoeckly, GE engineer in charge of the center's testing program, the addition of the new laboratory to the Divisions' facilities "will make the intricate task of aircraft-turbine testing many times simpler and faster." In addition to the new laboratory, the $25,000,000 center includes the following facilities: a row of test chambers for the operation of jet engines at sea-level conditions, low-temperature starting cells, test stand for turboprop engines, manufacturing, and assembly facilities.

While major component jet parts, such as the turbine and compressor, can be tested in the new laboratory under actual and varying flight condi-

tions, the full-size engine is tested under altitude conditions aboard the B-29 flying laboratory operated by GE at its flight test center near Schenectady, N. Y.

The new laboratory's full-scale compressor test stand consists of a closed-cycle air system in which air temperature, pressure, and humidity are controlled. Power is supplied to the compressor from a condensing tandem compound 30,000-hp steam turbine through a three-speed gear set making available to the compressor stand the full hp over the complete speed range. The steam-turbine driving unit was supplied on consignment by the U. S. Navy. Power measurements to the compressor are recorded by a precision torque meter on the gear output shaft.

The compressor test chamber is built to withstand maximum compressor-discharge conditions of pressure and temperature with compressor-inlet conditions ranging from sea level to 70,000-ft altitude. Refrigeration is obtained by a compression cooling and expansion cycle. Air from the compressor being tested is passed over the water-cooling coils, compressed further by a centrifugal compressor, cooled again by water coils, and further cooled by expansion through the air turbine which drives the centrifugal compressor.

Special Facilites for Full-Scale Turbine Testing

Full-scale turbine testing is carried on in a specially protected test cell to which carefully metered air from the compressor test stand can be fed. Special combustion chambers are provided to supply the turbine with gas at temperatures and pressures to which the turbine normally will be subjected under operating conditions. The power output of the turbine will be delivered to a special dynamometer capable of absorbing 30,000 hp. Provisions are made to operate turbines both with their own combustion systems and with the special combustion system supplying gas at uniform temperatures and pressures.

The combustion research stand will receive air from the compressor test stand and will be capable of testing complete engine-size combustion chambers under full-speed sea-level conditions.

For scale-model work and for evaluation of design constants for compressors, a scale-model test stand was built to investigate single stage and multistage operation. A closed cycle is used in which various weight-flows can be handled at pressure levels which can be varied from sea-level ram to 70,000-ft altitude over a temperature range from minus 70 F to plus 150 F. The stages under test are driven by a wide-speed-range cradle-mounted steam turbine which gives direct measure of power input.

Engine accessories and controls are developed in a separate section containing 16 distinct test stands. Controls, lubrication systems, fuel and oil pumps, starters, ignition, and other accessories can be developed under conditions simulating those encountered under worst flight conditions.

The Milwaukee Meeting

TWO papers by members of The American Rocket Society were presented at the semi-annual meeting of The American Society of Mechanical Engineers in Milwaukee, May 30 to June 5, 1948. They were:

The Design of Lightweight Corrosion-Resistant Pressure Vessels for Rocket Power Plants, by C. C. Ross, Jun. ASME, mechanical engineer, and R. B. Young, Aerojet Engineering Corporation, Azusa, Calif.

Design and Fabrication of Welded High-Strength Pressure Vessels, by J. J. Chyle, director of welding high-strength research, and H. W. Brock, manager, ordnance section, A. O. Smith Corporation, Milwaukee, Wis.

The text of these papers has been promised for publication in the JOURNAL, and it hoped to have them in time for the September issue.

Several papers on gas turbines were also presented. Some of these will probably be published in *Mechanical Engineering*. Preprints are available where a number is given at the end of the description. These papers were as follows:

Gas-Turbine Power Plants for Operation With Low-Cost Fuel, by John Goldsbury, Mem. ASME, mechanical engineer, turbine engineering division, General Electric Company, West Lynn, Mass.

The Gas Turbine With a Waste-Heat Boiler, by G. R. Fusner, Jun. ASME, gas turbine engineering division, General Electric Company, Schenectady, N. Y. (48—SA-13)

Construction of a Gas Turbine for a Gas-Locomotive Power Plant, by W. B. Tucker, Mem. ASME, turbopower development department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Continental and American Gas-Turbine and Compressor Calculation Methods Compared, by Franco Martinuzzi, director of research, Co-Ordination on Gas Turbines, Italian National Research Council, Rome, Italy.

Centrifugal and Thermal Stresses in Rotating Disks, by W. R. Leopold, Jr., Jun. ASME, design section, Wright Aeronautical Corporation, Woodridge, N. J. (48—SA-1)

Gyroscopic Effects on the Critical Speeds of Flexible Rotors, by R. B. Green, Jun. ASME, department of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass. (48—SA-3)

The Manifold Problem, by J. D. Keller, Mem. ASME, consulting engineer, Pittsburgh, Pa. (48—SA-2)

Increase of Dues

THE Secretary gave the following tally of the ballot of members on the question of changing the associate and student dues for the AMERICAN ROCKET SOCIETY:

Vote of Active Members

Approve increase of associate membership dues	140
Disapprove increase of associate membership dues	10
Approve increase of student membership dues	115
Disapprove increase of student membership dues	35

While the vote of associate members cannot be used in reaching the decision on the question, it was decided to include it in the report to the members as an indication of the wishes of the membership as a whole. This count was as follows:

Vote of Associate Members

Approve increase in associate membership dues	163
Disapprove increase in associate membership dues	60

Approve increase in student membership dues.....	145
Disapprove increase in student membership dues.....	78

According to the By-Laws of the AMERICAN ROCKET SOCIETY, a motion duly made, seconded, and passed by the Board of Directors must be published in the next issue of the JOURNAL regarding such a change in dues. Therefore, the following motion was made by the Directors and will appear in the June issue of the JOURNAL OF THE AMERICAN ROCKET SOCIETY.

Motion made by Mr. Gore, seconded by Mr. Healy and unanimously passed that the associate membership dues for the AMERICAN ROCKET SOCIETY be increased to $10 per annum; that the student membership dues for the AMERICAN ROCKET SOCIETY be increased to $5 per annum. Such increases to become effective with the quarter ending Sept. 30, 1948.

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DOVER, N. J.

Comments

Science Fiction

To the Editor:

Recent trends in science-fiction writing tend to include the bizarre superphysics of the world of tomorrow in a weak attempt to explain phenomena, which even nuclear power is incapable of performing. This trend is distasteful to many rabid readers of science fiction, and causes the loss of many readers of this type of material and subsequently the further degradation of science-fiction magazines.

If it were up to me to set standards for the magazines, I would eliminate all material that did not fit logically into, or could not be logically derived from, present-day physics. Such things as negative-matter bombs and hyperspacial tubes cannot be defined clearly because they have no basis in science. This pseudo science is practiced by authors in an attempt to lend an air of mystery and excitement to their novelettes but in doing so they insult the reader's intelligence. Authors who are more popular with the reader are those who use basic natural emotions such as fear, anger, and love, instead of pseudo science, and who do not confuse and confound the reader with things that lead him on stray tangents of thought.

Science fiction is amusing, enlightening, and broadening because of its thought-provoking qualities and characteristics. To me, there is no better way of reading for pleasure than settling in an easy chair with a good science-fiction magazine. But it has to be good to be interesting. Many today are not.

SUMNER SHAW[1]

[1] Student, Pratt Institute, Brooklyn, N. Y.

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Navy Seeks Qualified Men for Expanded Research Program

THE Navy Department is currently expanding three comparatively new, permanent laboratories in California, and implementing its scientific research and development program both geographically and in new fields of endeavor. Heretofore, the Navy Department's scientific centers have been concentrated in the eastern and western seaboard areas.

Two of the laboratories have been established as the logical outgrowth of programs carried on by universities during the war. The Naval Ordnance Test Station, China Lake (formerly Inyokern), Calif., 160 miles from Los Angeles, was originally an activity of the California Institute of Technology. Its present program involves research, development, and test work with ordnance equipment and explosives. The Navy Electronics Laboratory at San Diego, Calif., is the outgrowth of work done by the University of California. It is concerned with research, testing, and development of electronic control devices, detection equipment, instrumentation equipment, and training aids. The Naval Air Missile Test Center at Point Mugu on the coast of California, 60 miles north of Los Angeles, was established when the need for an installation became apparent as the result of the Navy Department's activities on guided missiles. The Test Center's activities are concerned with flight and laboratory testing and evaluation of guided missiles and their components.

Each of the establishments has current need for qualified personnel in a variety of scientific fields to staff its laboratories. Recently completed at the Naval Ordnance Test Station at a cost of $6,000,000 is Michelson Laboratory. Many more millions of dollars have been spent in equipment and facilities. Additional construction and facilities are planned for both the Air Missile Test Center and the Electronics Laboratory.

The work programs of the laboratories are planned, directed, and accomplished under the direction of a staff of civilian scientists. Extensive use is made of the council method of operation. Constant liaison is maintained with other research organizations, universities, scientific associations, and outstanding authorities throughout the nation.

Professional positions are available in the career service of the Federal government under Civil Service laws. Examinations are now open in the three scientific establishments in the following professional fields: chemist; mathematician; metallurgist; meteorologist; physicist; statistician; scientific research administrator; and scientific staff assistant.

Salaries for most of the positions range from $3397 to $9975 per year. Salaries are predicated on the level, knowledge, and experience required to discharge effectively the duties of a specific position.

Further information may be obtained from the Navy Department Joint Board of U. S. Civil Service Examiners, 1030 East Green Street, Pasadena 1, Calif. (*Mechanical Engineering*, May, 1948.)

Research Program Planned by Army for Reserve Officers

A COMMITTEE of scientists and engineers who hold commissions in the Organized Reserve Corps, met in the Pentagon on March 26–27, 1948, to consider the details of the Army's newly proposed research and development program for reserve officers. Meeting under the sponsorship of the Research and Development Group, Logistics Division, General Staff, which sponsors Army Research and Development, the Committee unanimously approved the contemplated program and

submitted a report strongly recommending its immediate establishment. It further recommended formation of procedures for optimum utilization of the technological skills of all reserve officers professionally engaged in the medical, biological, physical, and engineering sciences.

Under the program as proposed by the Scientific Manpower Section of the Research and Development Group, reserve officers who are professional scientists would be enabled to pool their technological competence for concentrated attack on Army research and development problems as well as to keep abreast of the Army's technological progress. It is also contemplated that the program will result in effective mobilization assignments for key scientists to insure rapid and proper mobilization in event of an emergency. (*Mechanical Engineering*, May, 1948.)

More GE Ceilometers for Army and Navy

NINETY ceilometers, electronic air-safety devices which automatically measure and record the altitudes and densities of clouds, are being produced for the Army and Navy, General Electric's Lighting and Rectifier Divisions have announced.

The ceilometer, already in use by weather bureaus, the Armed Forces, and several civilian air fields, operates equally well by night or day. A super-high-intensity quartz mercury lamp, smaller than a cigarette, mounted at the focal point of a searchlight mirror, sends skyward a beam of light.

Clouds overhead reflect the beam back to earth, and a detector unit, which includes a photoelectric tube pickup, and which is tuned to the same frequency as the light source, automatically analyzes the reflections, and transmits to a recording device a record of cloud heights.

The detector, placed about 1000 ft from the projector, scans the searchlight beam by swinging slowly from a horizontal to a vertical position and back again five times an hour.

G. E. CEILOMETER

Ceilometers make possible an accurate and rapid check of cloud ceilings at all times, expediting landing and take-off instructions, according to the engineers. Data recorded by the instrument are especially vital to safe flying at airports handling heavy traffic, they said.

One year ago, 125 of the devices were delivered to the Army and Navy for installation at the nation's military fields.

High-Temperature Metal

AN extremely hard metal that is said to retain its strength and resistance to corrosion at high temperatures has been developed by Kennametal Inc. of Latrobe, Pa.

This is a special "cemented carbide" composition manufactured by processes similar to those employed in making the carbides now used widely for cutting tools and wear-resistant parts, but with unique properties.

Reports indicate that it withstands temperatures that rapidly destroy conven-

tional carbides and the best cast alloys; resists thermal shock much better than ceramics; and has a specific gravity about one third that of tungsten carbide and two thirds that of steel.

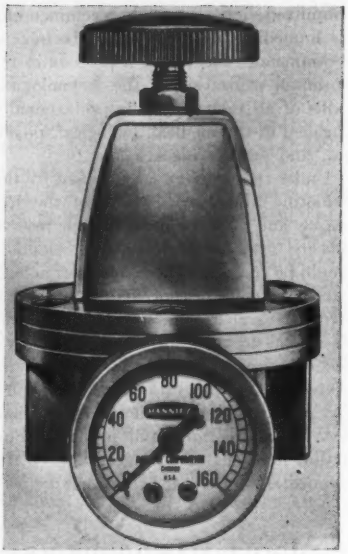
Pieces of this composition, grade K138, are said to have been heated to 2100 F for 48 hr without loss of strength. Neither does it change appreciably when heated to 1800 F and quenched in water. Air cooling from the same high temperature leaves no effect other than initial discoloration of the surface.

Its unique properties suggest many practical uses. Resistance to oxidation and hot gases, together with abrasion resistance because of high hardness, make it suitable for high-temperature structures, such as furnace parts, and guides for hot-rolled metal. Its lightweight and strength are advantageous for rotating parts exposed to high temperatures.

This heat-resistant material consists essentially of titanium carbide with cobalt as the bonding element. The titanium carbide has heretofore been used only as a minor ingredient of cutting-tool alloys. The metal can be formed into a great variety of shapes and sizes, with tolerances and finishes common to conventional cemented carbides. (*Mechanical Engineering*, March, 1948.)

Improved Air-Pressure Regulating Valve Announced

A NEW, improved automatic pressure regulating valve designed specifically for service on compressed air supply lines is announced by Hannifin Corporation, Chicago, Ill., builder of pneumatic- and hydraulic-production equipment. The regulator is for use on initial, or primary, air pressures up to 150 psi and can be set to maintain reduced, or secondary pressures ranging from 125 down to 5 psi. Distinguished outwardly by compact, streamlined appearance, the new development embodies a number of construction and operating features heretofore unavailable in a small size, moderately priced valve.



Through the use of an ingenious "free-floating" valve system, it is possible to back-off, or reduce, the delivered pressure under dead-end conditions merely by turning the adjusting screw. This has application on air-cylinder installations where it may be desirable to reduce the applied pressure without exhausting the cylinder. Pressure reduction through use of the regulator adjusting screw provides high precision control. This same design feature also insures positive protection against pressure build-up under dead-end conditions and contributes a stabilizing effect which is particularly desirable in handling sudden pressure changes such as may be occasioned by air-operated equipment.

Other features of the new regulator include: 1. Instrument type control knob and fine threaded adjusting screw for close regulation. 2. Steel insert in valve body for permanency and accuracy of thread engagement with adjusting screw. 3. Adjusting screw locknut for making permanent pressure settings. 4. All parts of noncorrosive materials. Die-cast parts treated to prevent corrosion. Nylon valve

seats. Textile reinforced synthetic rubber diaphragm. 5. Built-in fine mesh bronze strainer. Easily removable for cleaning. All internal parts accessible without disturbing pipe connections. 6. Durable, accurate pressure gage standard equipment with regulator. Nonlag dial action made possible by fast pressure response. Body threaded to mount gage on either side of valve.

Popularly named the "Air Warden" for its effectiveness in preventing waste of air, the new Hannifin regulator is being produced in two models. Model RD-1 is for 3/8-in. line piping and Model RD-2 is for 1/2-in. connections. Specifications and dimensions are contained in Bulletin NP-1005 which may be obtained by writing to Hannifin Corp., 1101 S. Kilbourn Ave., Chicago 24, Ill. (*Mechanical Engineering*, March, 1948.)

Fire-Resistant Panel

DEVELOPMENT of fire-resistant paneling that is said to protect human flesh within one inch of fire having a heat of 2200 F was announced recently.

Expected to reduce aviation fire hazards substantially and to have many other uses, the new panels are made of specially treated Du Pont "Strux" cellulose acetate plastic sandwiched between sheets of extremely thin (0.006 in.) carbon steel. Test panels are one-quarter inch thick and weigh less than a pound per square foot.

Civil Aeronautics Authority specifications for airplane fire-walls require material to withstand applied heat of 2000 F for a period of 15 min. In official tests, the new steel and plastic panel is reported to have withstood applied heat in excess of 2200 F for more than 30 min.

At the end of the test period the hand could still be held comfortably less than an inch from the panel on the side opposite from the fire.

Further unofficial tests have shown that the paneling stands up after more than an hour of exposure to a 2000-F flame.

An interesting sidelight on the construction of the panel is that the plastic core material, cellulose acetate, is not fire-resistant, being classified as slow-burning. In this application, however, as a result of special treatment by the Skydyne Corporation, Port Jervis, N. Y., developers of the paneling, the plastic, on exposure to heat, forms parchment-like layers. These layers act as a heat barrier.

Although the new paneling is intended initially for the aircraft industry, many other uses are foreseen where lightweight and fire resistance are considerations. (*Mechanical Engineering*, March 1948.)

Tonnage Oxygen

THE successful development of a new process for the manufacture of tonnage oxygen has been revealed by the Elliott Company, Jeanette, Pa. This development consumed approximately three years and has culminated in the completion of a pilot plant for 95 per cent purity gaseous oxygen. The Elliott process is said to be a completely new system and differs in principle from systems developed abroad and now used in this country.

According to Elliott, the outstanding features of the process are as follows:

1 The plant is not subjected to the necessity for periodic shutdowns for deriming in order to remove accumulated deposits of water and carbon dioxide. This is important when oxygen is to be used in a process which must be kept on stream continuously.

2 The system is completely immune to possible dangers of acetylene explosions since this system provides a straightforward and simple mechanical means of eliminating dangerous hydrocarbons from the system.

3 The process operates at reduced loads without sacrifice of efficiency.

4 The system is mechanically simplified. Like many other oxygen processes it depends upon reversing heat exchangers to precool the air to liquefaction temperature and at the same time freeze out water vapor and carbon dioxide. These accumulated deposits are periodically removed

by reverse flow of effluent nitrogen. In this system these reversals take place every three to four hours instead of every two to three minutes as is common in other known systems. Heat exchangers in this system require only one hot and one cold gas as contrasted to the multifluid exchangers required by existing processes. The switching valves in this system function less frequently than in other systems, and are also designed to operate at only slightly above atmospheric pressure. This feature reduces maintenance cost and gives added assurance of long life in service without mechanical failure.

5 All controls are automatic. They can be set to maintain constant purity over the entire range of operating conditions, or the purity can be varied at will by a simple adjustment. The automatic controls on the plant can be arranged so that the oxygen plant will automatically follow the process demands for oxygen without requiring manual attention from the operators.

6 The recovery of oxygen from the air is more than 97 per cent, with the result that minimum power is wasted and the nitrogen leaving the process is sufficiently pure for use as a chemical raw material for the manufacture of ammonia, nitric acid, fertilizers, or other processes requiring high-purity nitrogen gas. The system will simultaneously produce high-purity oxygen and high-purity nitrogen.

7 Oxygen as pure as 99.5 per cent can be made by the process. For tonnage production of commercial purity oxygen, analysis shows that it is more economical with the Elliott cycle to make 95 to 97 per cent purity oxygen and to dilute the product as required for the subsequent process. A plant designed for 95 per cent purity can also simultaneously produce 99.5 per cent purity welding-grade oxygen in quantities as required for this purpose.

It is stated that the power requirements and capital cost for the system should compare favorably with other systems.

The Elliott process is a truly low-pressure system in which the air is compressed to about 5 psig, conditioned, and cooled to below 300 F, and charged to a single fractionating column. The complete distillation takes place within this column which operates only a few pounds above atmospheric pressure. The entire plant is controlled by temperature distribution and liquid levels within the fractionating column so that all controls can be related to the desired purity and optimum distillation conditions for minimum power consumption. The gaseous oxygen is boiled off from the reboiler and delivered as the product at approximately atmospheric pressure after having been warmed up to room temperature in a heat exchanger. Effluent nitrogen from the top of the fractionating column which contains not more than $^1/_2$ of 1 per cent oxygen is used to provide the refrigeration for precooling the air entering the process. A small portion of this nitrogen is used for the removal of the deposited impurities from the heat exchangers while the bulk of it is available at approximately 99.5 per cent purity as a nitrogen product.

Like other oxygen systems refrigeration at extremely low temperature levels must be provided in order to make up for the warm end-temperature losses and the heat leak through the insulation into the system. This is accomplished in the system by an external refrigeration cycle which recirculates pure nitrogen from the top of the column through a heat-exchanger and compressor system, and finally obtaining the required amount of refrigeration by expansion through an Elliott turboexpander. This same external refrigeration system is also arranged to produce the liquid-nitrogen reflux required as overhead in the column for distillation. The unique arrangement of components provides for control of the refrigeration and reflux independently of the quantity of air being charged to the system for distillation, so that the controls will automatically compensate for changes in demand and weather conditions for uniformity of product and minimum use of power.

The Elliott pilot plant has completed a continuous nine-week run during which time the operation was entirely automatic except during periods of obtaining special test data. The performance confirmed

the correctness of design and from the analysis of the data obtained it was demonstrated that the plant could run indefinitely. Regular acetylene analyses were made throughout the process and at no time was any trace of acetylene ever found in the liquid oxygen where the explosion hazard would exist.

The possibilities of these oxygen plants are intriguing and commercial plants are envisioned which will produce more than 25,000,000 cu ft (1000 tons) of oxygen per day. It is expected that with the use of oxygen the output and economy of open-hearth furnaces, blast furnaces, Bessemer converters, and electric furnaces can be greatly increased.

Quantity oxygen is also an essential of the new synthetic-gasoline processes which are being planned. The use of oxygen combined with natural gas opens up a new source of supply of much-needed gasoline, fuel oil, and chemicals. Coal can also be used instead of natural gas, in the production of gasoline and fuel oil, and it is said this development can make the United States entirely independent of the rest of the world for liquid fuels for possibly as long as 1000 years. Even substitute natural gas can be made right at the mines by the gasification of coal through the use of oxygen, and piped to large cities and industries.

Astro-Window

A NEW astro-window through which navigators aboard long-range stratosphere airliners will "shoot" the stars, even in daytime, has been developed by Bausch & Lomb Optical Company, Rochester, N. Y.

Designed for Air Force and commercial ships, the streamlined window consists of two plates and is said to be capable of withstanding a total force of $3^1/_2$ tons. Its surface projects only $2^1/_2$ in. above the ship's skin as compared to 6 in. in the old-type speed-retarding astro-domes.

The astro-window's outer plate is a large optical lens that has been ground and polished to reduce refraction errors regardless of the angle of the sighting instrument. The inner plate is plastic and houses a defrosting system that should prove invaluable to celestial navigators.

It is reported that on stratosphere flights the astro-window eliminates much of the difficulty encountered by navigators in shooting the stars, even the dimmer ones, regardless of the weather or the hour of day or night.

The higher man flies, it is said, the plainer the stars become, allowing for continuous and accurate aircraft fixes anywhere over the earth. Contrary to popular notion, the higher you go, the simpler sextant observations become. In the stratosphere the sky tends to become darker and stars are readily seen in the daytime.

On overseas hops, fixes are taken about every half-hour with modern bubble sextants, two of which are standard equipment on long-range aircraft. (*Mechanical Engineering*, April, 1948.)

Upper-Atmosphere Research

CAPTURED German V-2 rockets, which can carry a ton of equipment more than 100 miles up, have enormously increased our knowledge of the earth's outermost atmosphere. Several V-2's have been fired in New Mexico by the Army in a co-operative research program with a number of government and university laboratories. The results, published in technical reports, have been comprehensively reviewed by Ernst H. Krause of the Naval Research Laboratory, in a paper for the American Philosophical Society and are reported in the *Industrial Bulletin* of Arthur D. Little, Inc., April, 1948.

The V-2 is 46 ft long and 5 ft in diameter. To keep it pointed in the right direction, the propelling gases from the rocket motor play on carbon vanes located in the tail and controlled by gyroscopes. It rises slowly from the ground and goes faster and faster until it reaches a speed of about 3500 mph, when the fuel is exhausted. There-

after the vanes cannot control the direction of flight and the rocket may roll, pitch, and yaw about, a serious disadvantage from the experimental viewpoint. On subsequent flights, the rocket will have a device to keep one instrument, the spectrograph, automatically pointed at the sun.

The rocket spends about five minutes above the 30-mile level, and some data taken at this time are radioed to the ground. To recover spectrographic and photographic data, the rocket is broken up—weakened by a small charge of TNT, it breaks on contact with the dense atmosphere—and the pieces tumble down relatively slowly. Even after extremely high flights, equipment often lands in fair condition and, occasionally, intact.

The present research concerns cosmic rays, the ionosphere, the spectrum of the sun, and measurements of pressure, temperature, and composition of the upper atmosphere. Much new and some totally unexpected information has been collected. Since cosmic rays change before they reach the earth, observation of primary rays has heretofore been impossible. The V-2 reaches the region of the primary rays and passes through the zone where the changes occur. This information will lead to a better understanding of what cosmic rays are and where they fit into the scheme of things.

Previously the radiant energy from the sun could be examined only at altitudes up to 20 miles. At 100 miles, wave lengths much shorter than those previously observed were found, but a layer of ozone lying between 20 and 40 miles absorbs these waves before they reach the earth.

Despite difficulties involved in dealing with the great variations of temperature and pressure found throughout the atmosphere, instruments for measuring these values were devised. At about 80 miles, pressures were recorded as low as one-ten-millionth of the atmospheric pressure on earth, corresponding to a high artificial vacuum. It is believed that beyond the measured range, at 100 miles, the pressure is about 100 times lower. Striking variations in temperature were noted. Temperature drops rather steadily with altitude until it reaches about −63 F at ten miles, and varies slowly for another ten miles. From 20 to 30 miles up, it increases steadily to 130 F, drops again to −100 F at about 50 miles, and finally rises again, reaching about 212 F at 75 miles.

On various flights, special strains of seeds and fruit flies were taken up 106 miles to determine whether radiation above the atmosphere might produce mutations. On recovery, they showed no detectible changes, but this is not conclusive, since the specimens were shielded by metal.

The next several years should see interesting developments in upper-atmosphere research, now that the groundwork and techniques have been perfected.

High Temperature Measurements

GAS temperatures up to 5000 R can be measured to an accuracy of one per cent with the system developed by the Fairchild Camera and Instrument Corporation. The system is described by David William Moore, Jr., in the May, 1948, issue of the *Aeronautical Engineering Review*, pages 30–34.

The Fairchild system consists essentially of two small orifices with a cooling tube between. The rate of discharge of a gas through an orifice is a function of the pressure drop and of the absolute temperature of the entering gas. When, therefore, the same gas is caused to pass through two orifices an equation can be formed which will give the temperature entering the first orifice when the temperature entering the second orifice, the orifice constants, and all the pressures are known. This second temperature can be made as low as desired, and can be measured by any convenient type of thermometer.

The first orifice is the only part exposed to the high temperature.

The article contains diagrams and photographs of the apparatus and discusses tests and problems yet to be solved

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national Societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to the engineering profession and is operated on a co-operative nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. Apply by letter, addressed to the key number indicated, and mail to the New York office. When making application for a position include six cents in postage for forwarding application to the employer and for returning when necessary A weekly bulletin of engineering positions open is available at a subscription of $4.50 per quarter or $14 per annum.

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POSITIONS AVAILABLE

MECHANICAL ENGINEER with experience in design and development of jet-engine controls and aircraft hydrochemical equipment, to design and lay out aircraft accessories. Salary, $4800 a year. Location, New York State. W-9770.

DEVELOPMENT ENGINEERS, electrical graduates, with minimum of five years' experience in electronics, control circuits, computing mechanisms, or servomechanisms. This experience is essential. Salary open. Location, New York State. Y-194.

ELECTRONIC ENGINEER AND PHYSICIST, B.S. degree, with three years' experience in any one of the following fields: Servomechanisms, gyroscopics, instrumentation, audiofrequency and electromechanics, to do design and development work in the guided-missile field. Salary, $4800–$6000 a year. Location, Michigan. Y-219.

DESIGN AND DEVELOPMENT ENGINEERS, graduates, with advanced training and responsible experience in design and development. (*a*) Should be qualified to do work in servomechanism design, airborne fire-control computers and airborne-radar design, such as wave guides, Radomes, R. F. electromechanical precision-instrument designs. (*b*) Should be qualified to do work in radar systems planning antenna design, circuit design, servo and control design and field test of complex electronics equipment. Salaries, $3600–$9000 a year. Location, Maryland. Y-391.

PHYSICISTS. (5) One for research and development work in the field of guided missiles including development of methods of stabilization and control, and research and development of over-all missile systems. Salary range: $4149–$7102 a year. (6) One for research and development work in electronic-control and guidance systems including development of microwave transmission lines, filters, resonators, the development of antenna designs and radiation and collection systems, and the research and development of electronic circuits for the systems, including wide band video amplifiers, gating circuits, track circuits, memory circuits, phase comparators, etc. Salary range: $3397–$7102 a year. Y-434(*a*).

ENGINEER TECHNICAL LIAISON REPRESENTATIVE. Formal education in physics or engineering preferred. Research and development background in fields of aircraft or guided missiles. Experience as editor of technical reports and surveys or postgraduate physics teaching might provide good background. Also extensive experience in public contact desired. Location, Maryland. Y-463-785.

ENGINEERS. (*a*) Physicist, background in electronics as applied to instrumentation of fire-control computers. Knowledge of general physics of fire-control problems and understanding of gyrodynamics. (*b*) Radar engineers, experienced in the theory and design of electronic circuits associated with automatic gun-laying radars. Must be capable of independent thought in

solving complex circuit problems including noise eliminations. Salaries commensurate with ability. Location, Missouri. Y-540.

Navy Vacancy List

LISTED below are a few of the positions open in the Navy Department, with headquarters in Washington, D. C. Information concerning these and other vacancies may be obtained from the Employment Office, Room 1213, Main Navy Building, 17th and Constitution Avenue, N.W., Washington, D. C.

AERONAUTICAL ENGINEER, P-5 (A-858) P-802 Series. B.S. degree in aeronautical engineering plus 5 years of progressively responsible professional engineering experience including at least 3 years of difficult and important work in pilotless aircraft. To act as technical assistant to the head of the section which institutes, develops, executes, and administers programs for the design, development, and test of all types of pilotless aircraft. Will serve as an expert consultant and technical adviser on problems relating to the development, improvement, and experimental testing of special pilotless aircraft. Will be responsible for evaluating and determining the completeness and adequacy of design data submitted by contractors to establish that the design will fulfill requirements.

CHEMIST, P-5 (I-341) P-1312 Series. Degree in chemistry with 4 to 6 years of progressive experience in inorganic or physical chemistry. To carry out research and investigations in the field of radiological contamination and decontamination relative to shipboard structure and materials.

PHYSICIST, P-5 (I-70) P-1370 Series. B.S. degree with major in physics and a broad background in theoretical or experimental physics in the field of acoustics or electronics. For research and development in the field of physical phenomena, related to underwater acoustics or electronics.

ELECTRONICS ENGINEER, P-5 (I-816) P-840 Series. B.S. degree in electrical engineering or physics and at least 4 years' progressive experience in the fields of sonar, electronics, underwater acoustics or related fields. To supervise and direct research, development, and design functions pertaining to submarine sonar equipment and associated training aids.

SCIENTIST (ASTRONOMER), P-2 (B-1223) P-1304 Series. Applicants must have a Bachelor's Degree in astronomy, plus at least one year of professional experience in astronomy involving the performance of responsible tasks in connection with either the collection and interpretation of astronomical observations, or astronomical computations or at least 5 years of successful and progressive technical astronomical experience of such a nature as to enable him to perform successfully at the professional level. To make astronomical computations or eclipse data occultations, ephemeral of the sun, moon, and planets and other star data for the purpose of checking results previously arrived at by other methods of calculation. Requires knowledge of the methods of making such astronomical computations and use of higher mathematics, including spherical trigonometry, differential calculus, least squares solution, etc.

MATHEMATICIAN, P-3 (F-474) P-1344 Series. Equivalent of Ph.D. in mathematics with extensive practical experience, wide familiarity with applied mathematics, particularly analytical mechanics, dynamics, aerodynamics, etc. Under general supervision of the chief mathematician to carry out specially assigned studies of ordnance equipment concerning the operation of specific components, over-all systems, the results of experimental or operational tests and theoretical predictions of performance. These activities are in connection with evaluation studies and other analyses of weapons and weapon systems such as underwater ordnance, antiaircraft ordnance and other types of ordnance problems involving mathematical, fiscal, and operational analyses.

PHYSICIST, P-7 (I-134) P-1370 Series. Ph.D. with an outstanding gift for creative thinking and reputation for technical and scientific reliability and soundness of judg-

ment, plus 8 years of progressive responsible experience in the field of physics. Must have a wide knowledge of all phases of theoretical physics. To direct the design, construction, procurement, installation, operation, and maintenance of gear for the sweeping of all types of mines and mine countermeasures.

MATHEMATICIAN, P-7 (F-473) P-1344 Series. Ph.D. in mathematics plus at least 4 years of broad, progressively responsible experience involving the use of the principles of theoretical or applied mathematics in the solution of scientific problems. This experience must have demonstrated the applicant's ability to organize, direct, and co-ordinate research or similar difficult work of an important character in mathematics, including work in the physical-science field. The applicant must have demonstrated a marked capacity for original research in mathematics and show a knowledge of the principles underlying other physical sciences such as engineering, physics, chemistry, etc. Under the general technical guidance of the chief mathematician for the Bureau of Ordnance, to act as his assistant in the administrative, professional, and technical supervision of the Evaluation and Analysis Group. To act for the chief mathematician in his absence, assuming full responsibility for initiating and reviewing projects, and for providing such expert technical advice and consulting services as may be requested in connection with the effectiveness of proposed and existing weapons. To act as alternate for the chief mathematician and as representative in attending scientific meetings and conferences and in serving on committees.

PHYSICIST, P-5 (K-220) P-1370 Series. M.S. degree in physics plus at least 2 years' experience in research, a considerable part of which was in radiology or atomic fissions and 2 years' related additional experience. To plan, conduct, and supervise research in the field of radiological contamination and decontamination as applied to structures and construction materials; to establish decontamination procedures; and to prepare specifications of equipment to minimize or prevent contamination.

TECHNOLOGIST (RADIOLOGICAL), P-4 (I-583) P-1390 Series. B.S. degree in electrical engineering with at least 3 years' experience in radiology or allied field. To prepare, check, and revise plans of electrical systems and apparatus for power on all types of naval vessels. Prepare original designs of electrical installations for naval vessels, investigating designs of new equipment to determine suitability.

ENGINEER (ELECTRONICS), P-4 (I-514) P-840 Series. Degree in physics or engineering with research and development experience in new types of underwater sound and sonar devices. To conceive and develop new models of sonar devices, sono buoys, training aids, etc., and to participate in tests of such equipment.

MATHEMATICIAN, P-5 (F-471) P-1344 Series. Degree in mathematics or physics with 4 years of experience in applying mathematics to actual physical problems. Under general supervision of the chief mathematician for the Bureau of Ordnance, to be responsible for carrying through to completion, evaluation projects in studies of weapons and weapon systems such as underwater ordnance, hydraulic ordnance, and such other types of ordnance problems as are assigned to the Analysis and Evaluation Group involving mathematical, physical, and operational analyses.

Aberdeen Proving Ground Positions Open

APPLICATIONS for Civil Service positions are being received at Aberdeen Proving Ground for filling approximately 32 job openings. To apply for positions

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made in our machine shop and labs
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Phone: Elizabeth 3-2135

fill out Standard Federal Employment Form 57 and mail to Civilian Personnel Division, Room 9, Headquarters Building, Aberdeen Proving Ground, Maryland.

Requirements and duties for some of the available positions follow:

AUTOMOTIVE ENGINEER, P-3, $4149.60 per annum. Requirements: Bachelor's degree in engineering or equivalent with 2 years' professional-engineering experience, 1 of which must be in appropriate branch. Duties: Conducts engine dynamometer and sprocket tests on track-laying vehicles for operational and performance characteristics.

ORDNANCE ENGINEER, P-3, $4149.60 per annum. Requirements: Bachelor's degree in engineering or equivalent with 2 years' professional-engineering experience, 1 of which must be in appropriate branch. Duties: Either (1) conducting long-term storage research program involving storage of material ranging from fire-control equipment and carbines to 240-mm howitzers, or (2) conducting development tests in the field of shoulder weapons and machine guns, or (3) conducting tests for the purpose of evaluating performance characteristics of all types of bombs, bomb fuses, and aircraft pyrotechnics.

ORDNANCE ENGINEER, P-6, $7102.20 per annum. Requirements: Bachelor's degree in engineering or equivalent with 4 years' appropriate professional-engineering experience of a high order, 2 of which must be in the specialized field. Duties: Serves as Chief of the Rocket Branch in the Ballistic Research Laboratories, directing basic research on rockets.

ORDNANCE ENGINEER, P-7, $8179.50 per annum. Requirements: Bachelor's degree in engineering or equivalent with 4 years' appropriate professional-engineering experience of a very high order, 2 of which must be in the specialized field. Duties: Assistant to the Chief of the Exterior Ballistics Laboratory, plans and supervises research in exterior ballistics.

MECHANICAL ENGINEER, P-2, $3397.20 per annum. Requirements: Bachelor's degree in engineering or equivalent with 1 year appropriate professional-engineering experience. Duties: Either design of model projectiles and instrumentation for aerodynamic and transonic ranges, or design and drafting of mechanical design connected with air-flow research, or design, development, and modification of mechanical aspects of optical instruments.

CHEMIST, P-3, $4149.60 per annum. Requirements: Bachelor's degree in chemistry or equivalent with 30 semester hours in chemistry plus 2 years' professional experience in chemistry, 1 of which must be in appropriate branch. Duties: Research and development of hydraulic brake fluids, hydraulic brake preservatives, antifreeze components and inhibitors, and shock-absorber fluids.

PHYSICIST, P-4, $4902.00 per annum. Requirements: Bachelor's degree in physics or equivalent with 24 semester hours in physics, plus 3 years' professional experience in physics, to conduct research in the field of blast waves in air, detonation phenomena, or fragmentation phenomena.

PHYSICIST, P-6, $7102.20 per annum. Requirements: Bachelor's degree in physics or equivalent with 24 semester hours in physics, plus 4 years of appropriate professional experience of a high order in physics. Duties: (1) Chief of a branch of a Laboratory which studies and conducts theoretical research in blast, penetration, incendiary, fragmentation, hollow charge, and detonation effects of weapons upon targets; or (2) chief of a branch which conducts research both experimental and theoretical in field of interior ballistics; or (3) conducts research for purpose of determining basic design data to be applied to the development of optical instrumentation for use in full-scale free flight ballistic measurement.

PHYSICIST, P–5, $5905.20 per annum. Requirements: Bachelor's degree in physics or equivalent with 24 semester hours in physics, plus 4 years of broad professional experience in physics. Duties: Performs research in the field of either high pressures or blast waves in air, detonation phenomena and/or fragmentation phenomena.